



# Advanced Visualization for Operational Assessment

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Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE <b>JUN 2006</b>		2. REPORT TYPE		3. DATES COVERED <b>00-00-2006 to 00-00-2006</b>	
4. TITLE AND SUBTITLE <b>Advanced Visualization for Operational Assessment (Briefing Charts)</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Science Application International Corporation,10260 Campus Point Drive,San Diego,CA,92121</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>					
13. SUPPLEMENTARY NOTES <b>The original document contains color images.</b>					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES <b>18</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			



# Structure of the Talk

- Introduction
- Cognitive Systems Engineering
- Systems Engineering Analysis
- Visualization Interface Concept Development
- Concept Evaluation
- Conclusions and the Way Ahead



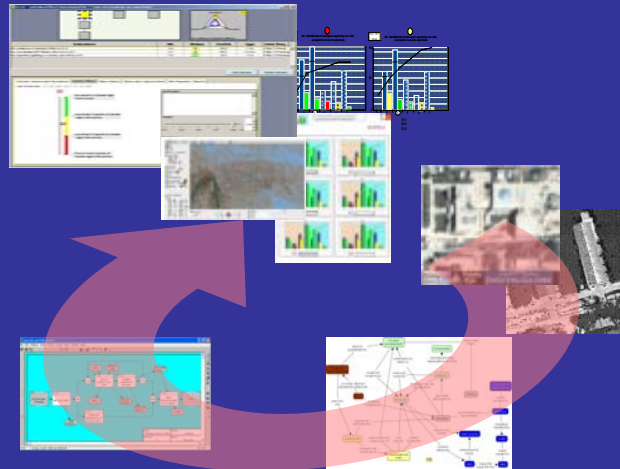
# Operational Effects Assessment Visualization Tool (OEAVT)

## Objective

Decision-quality support to assessment team in defining critical indicators, managing assessment data, determining operational effectiveness, visualizing/understanding complexity and uncertainty.

## Approach

- Analysis of assessment domain
- ID assessment functions
- ID requirements
- Design/Refine-Prototype
- Build
- Operational test



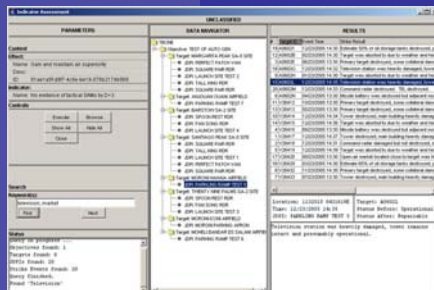
## Benefits to Warfighter

- Decision-quality knowledge to the commander
  - Continuous operational assessment tied to objectives
- Sensemaking of battlespace effects
  - Uncertainty management
  - nth-order causal understanding
- Faster decision times

## Technologies

- Information Visualization
- Knowledge Management
- Intelligent Interface Agents
- Advanced Search/Data Mining

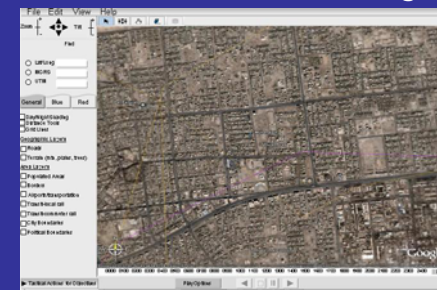
## Evidence Accrual



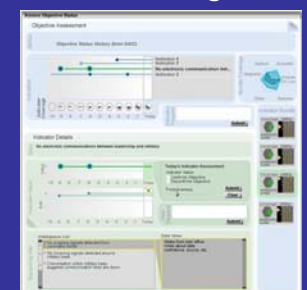
## Operational Assessment



## Prediction & Forecasting

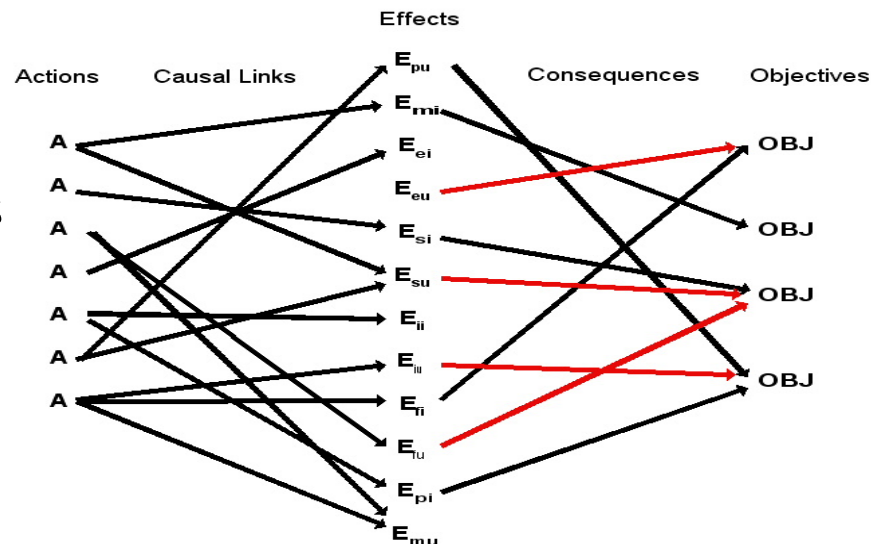


## Indicator Mgmt



# Effects-based Assessment: Operational Issues

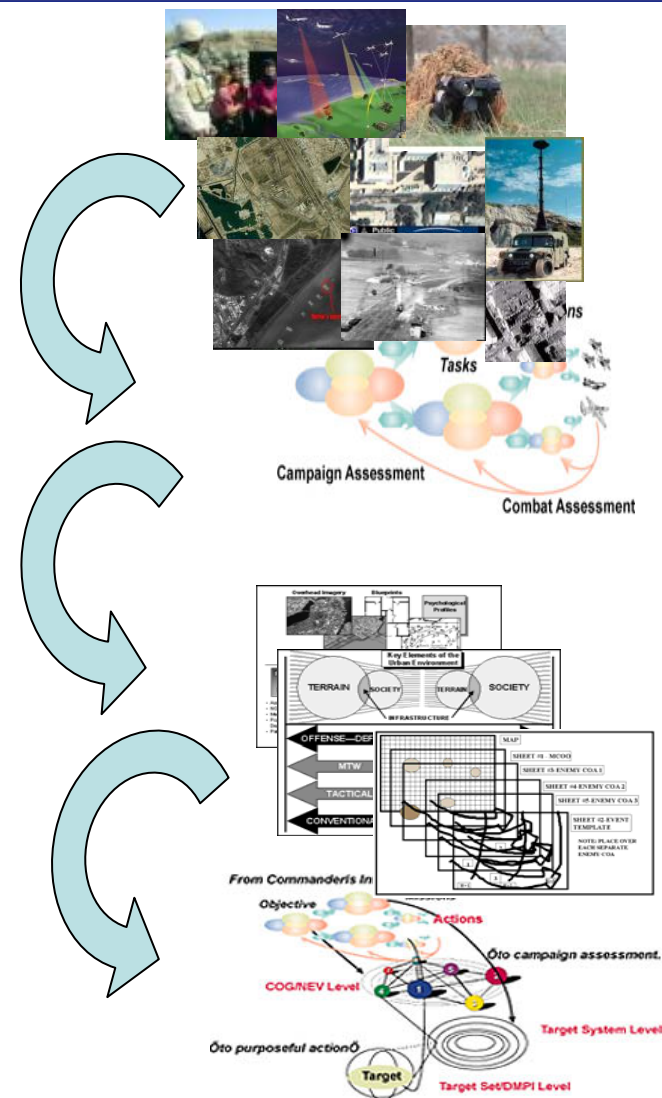
- All operations have complex effects.
  - Desirable and undesirable effects
  - 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> order effects
  - Time delays introduce uncertainty and risk
- Understanding the implications of operations is a multidimensional problem.
  - Effects can be strategic, operational, physical, psychological, ...
  - System of systems is a major conceptualization & modeling challenge



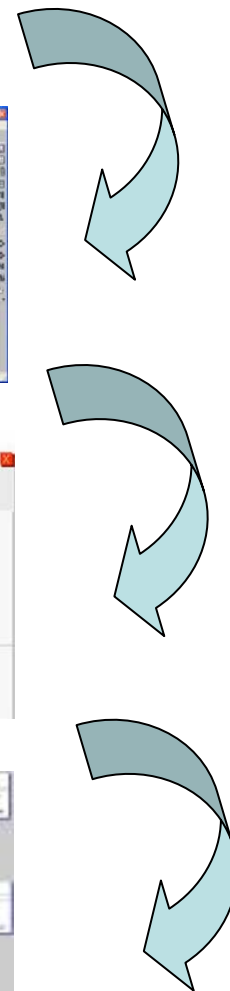
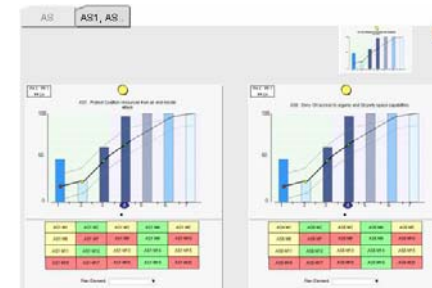
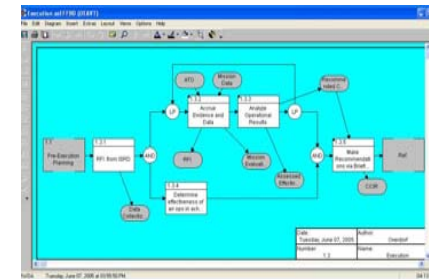
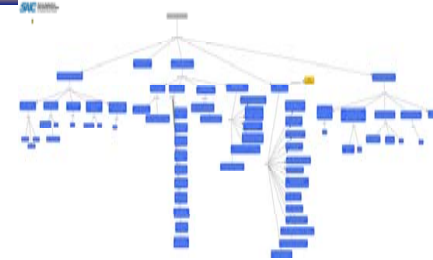


# Effects-based Assessment: Human Performance Issues

- **Data management**
  - What to measure, when to measure, how often to measure?
- **Dynamic assessment**
  - Finding appropriate indicators and measures
  - Integrating results in real time: A data aggregation problem, an interpretation problem.
- **Plan troubleshooting**
  - How does one decide when to “stay the course” or to recommend changes the strategic plan?
  - How to evaluate the efficacy of potential changes?








- EBA Domain analysis and cognitive system engineering
- System engineering analysis and requirements
- Visualization concept development
- Develop prototype

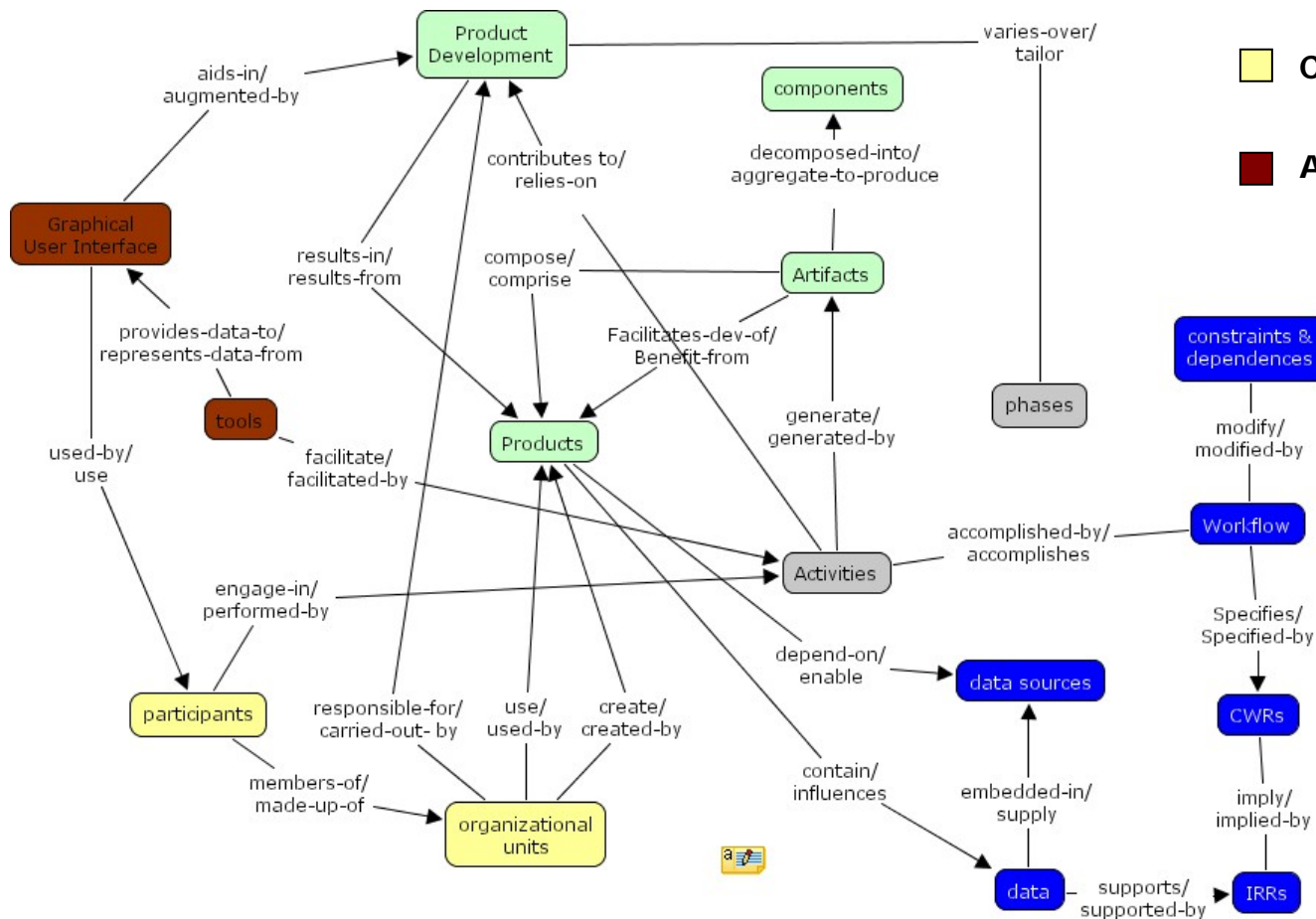




# Concept Mapping: Basic Information

- Five “views”
- Some overlap

-  Work management
-  Cognition
-  Products
-  Collaboration
-  Automation





Identified the following cognitive work for EBA:

## Pre-execution

- **Assessment planning**
- **Determine adversary capabilities & likely COA**
- **Develop JAOP**
- **Develop STTM**
- **OAT mgmt of EBA**
- **Predict ops effectiveness**

## Execution

- **Accrue evidence**
- **Analyze ops results**
- **BDA**
- **Execution tracking**
- **Functional damage assessment**
- **Integrate mission assessment**
- **Mission assessment**
- **PDA**
- **Target system assessment**

## Post-execution

- **Inter-division feedback**



# Decision Requirements Tables

- Identify and characterize assessment decisions that will drive visualization requirements
  - Task
    - Critical cues
    - Critical decisions
    - Common errors
    - Actions
    - Tools used
    - Collaboration and communication
    - Data used
    - Requirements



# DRT Example

- Recognize actionable changes in ongoing air ops
- Assess feasibility of plan changes

Critical Cues	Critical Decisions	Actions	Common Errors	Tools Used	Communicates with	Data Used	Requirements
*Change in pathways *Change in weather *Etc.	*Determine when changes have been made in ongoing air ops	*Monitor activity trends in areas indicated by critical cues *Monitor indicators against predictions and time		*TBMCS	*ISR *Plans team	*MISREPS *INTSUMS *DISUMS *Combat assessment	*The system shall allow and aid in recognizing actionable changes in ongoing air ops
• WOE • Time • Guidance • Resource profiles	*Determine if resources available for corrective actions *Determine what to change & amount of change *Determine WOE for each objective *Determine priorities	*Make recommendation *Predict intended and unintended effects of changes *Infer 1 <sup>st</sup> , 2 <sup>nd</sup> , 3 <sup>rd</sup> order effects associated with potential changes		*IWPC *TBMCS	*ISR *Plans team *Combat Ops	*TPFID *ATO *Guidance	*The system shall determine if resources are available for corrective actions  *The system shall determine amount of change to plan, and what to change



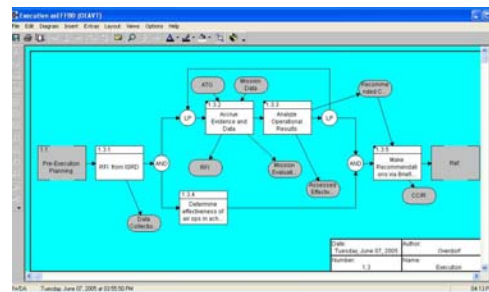
# CORE Systems Analysis



- CORE: Commercially available CASE tool
  - Allows management of the whole project
  - A wide range of information
  - DES supports tradeoff & what-if analysis
  - DoDAF compatibility
- What information we put into it
  - All concept map and CDA information
  - Other information specified by SMEs
- Vetted with SME input
- 108 functions

# CORE Diagram Examples

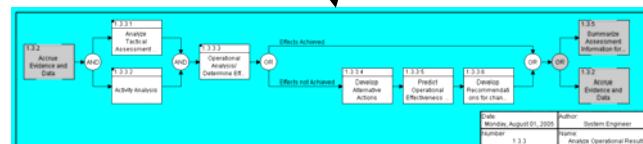
## Execution



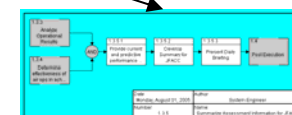
Can be used to generate SV-4 descriptions



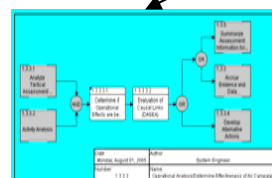
Accrue evidence and data



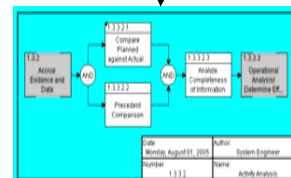
Analyze operational results



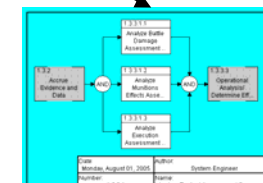
Make recommendations



Activity analysis



Determine effectiveness of air campaign



Analyze tactical assessment summaries



# Visualization Interface Concept Development

**Scenario Element**

Operational execution

**Operational Requirement**

Indicator Management

Evidence Accrual

Prediction and Forecasting

Operational Assessment

Reporting

**Capability/Support Requirement**

Intelligent queries

Data mgmt  
Data mining

Temporal assessment

Cascading effects

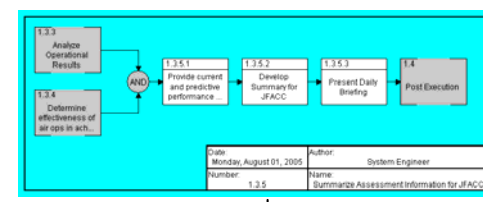
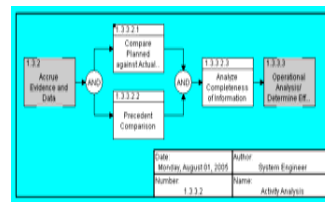
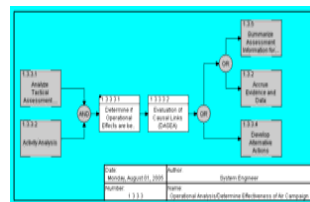
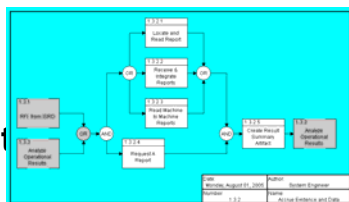
Causal link analysis

Plan troubleshooting

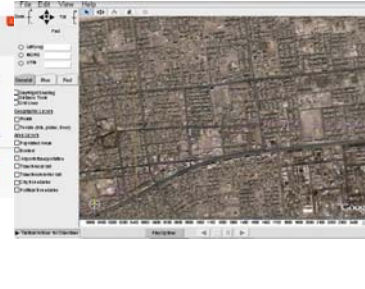
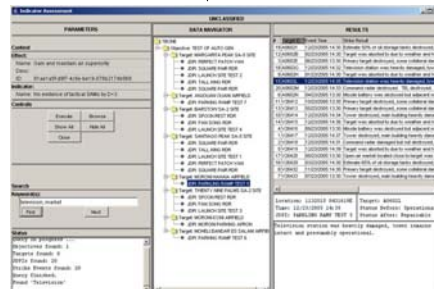
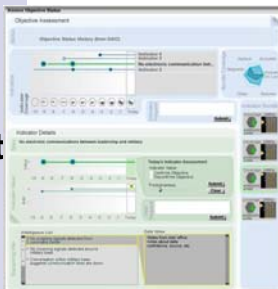
Uncertainty visualization

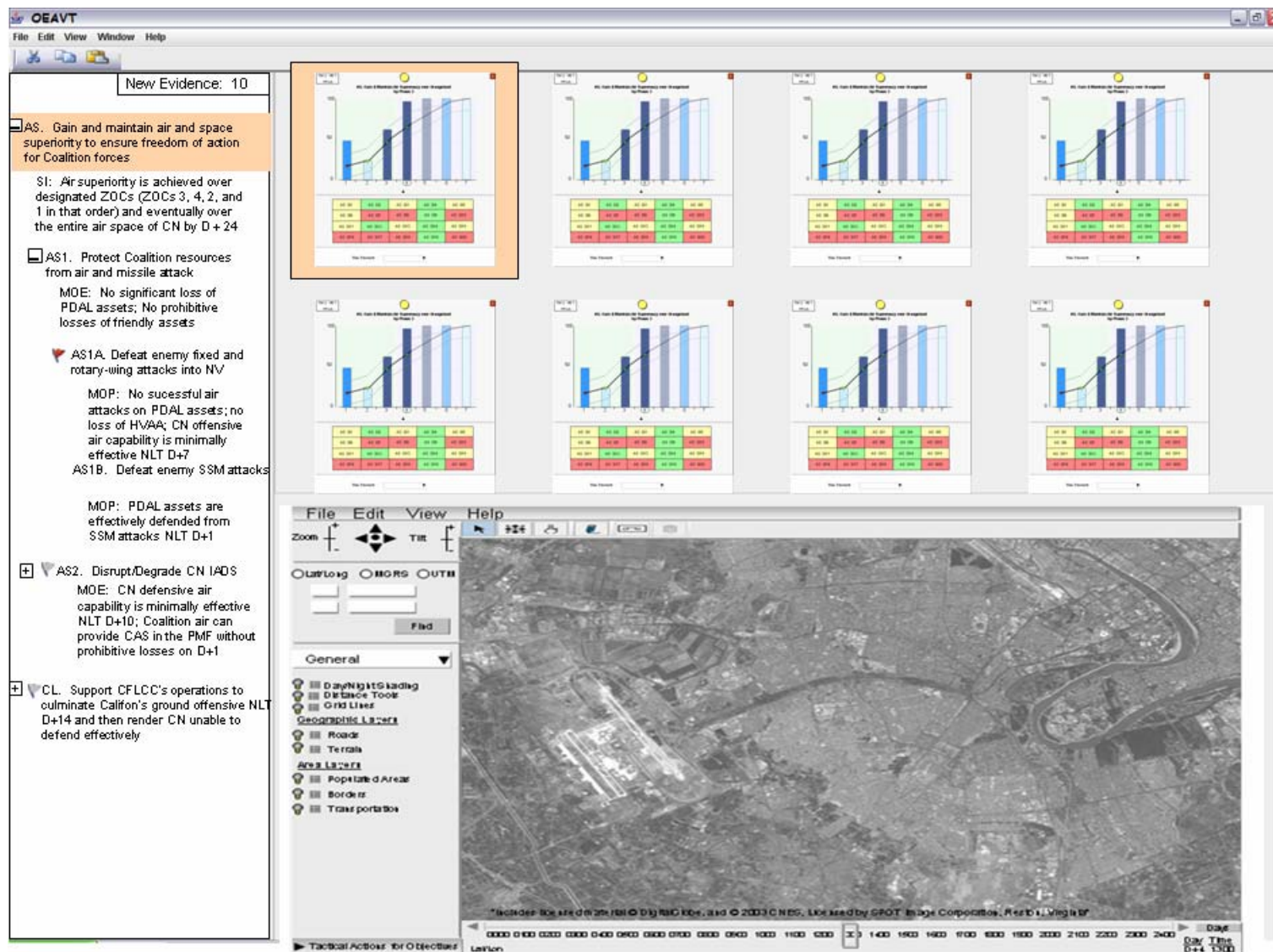
“Live” briefing capability

**Functional Requirement**



**Concept**









# Concept Evaluation

- Purpose: Demonstrate visualization concepts for an integrated ops assessment system
  - Feedback on concept
  - Feedback on implementation



# Conclusions

- This methodology enables a meaningful integration of cognitive systems analysis with accepted system engineering and technology development practice.
- The cognitive and perceptual work involved in EBA can be captured by a limited, manageable number of hierarchically structured functions.
- Visualization technologies must be both broad and deep for success in an EBA domain.



# The Way Ahead: Potential Long-term Direction

Development Focus	Potential Technology Solutions
PMESII visualization	<ul style="list-style-type: none"><li>- Hierarchical task network with recursive task blocks</li><li>- 3-D rendering</li><li>- Fisheye view on demand</li></ul>
Intelligent queries	<ul style="list-style-type: none"><li>- Queries for spatial, temporal and probabilistic content</li><li>- Intelligent, automated data acquisition</li></ul>
Causal link analysis <ul style="list-style-type: none"><li>• between actions and effects</li><li>• cause – effect latencies; latencies in observing effects</li><li>• temporal effects</li></ul>	<ul style="list-style-type: none"><li>- Influence nets</li><li>- Colored Petri Nets</li><li>- Hybrid dynamical systems</li><li>- Temporal causal graphs</li><li>- Causal graphs &amp; event calculus</li><li>- Timed failure propagation graphs</li></ul>
N <sup>th</sup> -order effects	<ul style="list-style-type: none"><li>- Temporal causal graphs</li><li>- Causal graphs &amp; event calculus</li></ul>



# Questions